EECS 243 – Advanced IC Processing and Layout

Fall 2000 **Office Hours** **Prof. A. R. Neureuther,**
Tu, Th 3:30-5 **M, Tu,Th, (F) 11am** **510 Cory Hall, 2-4590**
299 Cory **W 10** **neureuth@eecs**

Homework Assignment # 5, Due Tu, Oct 10th, 00

Reading for Week #6: PDG 201-203, 273-281, 256-271; ARNL2 123-152.

5.1 Electron-beam system resolution and current

Complete the following table to compare the resolution and beam current capabilities of a generic SEM and a generic electron beam writer. The SEM has a thorium coated tungsten field emitter tip with $\Delta E = 0.2$ eV, semi-angle of 3-5 mR, a current on the vicinity of 200 PA and a final lens focal length of 2 cm. The electron beam writer has an LaB_6 source with brightness of 10^5 $Acm^{-2}sr^{-1}$with $\Delta E = 2$ eV, a semi-angle of 5 mR and a final lens focal length of 20 cm. Assume C_C equals the focal length and that C_S is 2.5 times larger.

System	V	Source	ΔE	α	I	d_d	d_s	d_c	d_0	d (resolution)
	kV	type	eV	mR	pA	nm	nm	nm	nm	nm
SEM	1	FE	0.2	3	100				0	
SEM	20	FE	0.2	5	300				0	
Lith 25nm	35	LaB_6	2	5						25
Lith 70 nm	35	LaB_6	2	5						70

5.2 Electron-material interaction

Consider three electron beam systems exposing resist with density 1.2 on a silicon substrate. One operates at 1 keV, another 20 keV and a third 35 keV.

a) Determine the Grun range in resist for each system.

b) Determine the electron energy deposition at the resist surface in $(J/cm^3)/(\mu c/cm^2)$ for each.

c) Determine the standard deviation of the forward scattering according to $s_f = \left(\frac{0.5z}{V}\right)^{1.75}$

where V is the beam voltage in kV, z is the depth measured in nm and σ_f is in nm. Use a depth of 10 nm at 1Kev and a depth of 200 nm for 20 and 35 keV.

5.3 Shot noise

EUV photons with a 13.4 nm wavelength expose a resist with an absorption constant $\alpha = 5\ \mu m^{-1}$ at an exposure dose of 20 mJ/cm^2.

a) Determine the deposited energy density at the surface. (Neglect reflection.)

b) Determine the number of photons absorbed per unit volume and the average distance between absorbed photons.

c) Find the probability that a sphere of radius 3nm has no exposure events inside.

d) Determine the radius of a sphere that has a probability of 10^{-20} of having no exposure events inside. (A shot noise tolerant linewidth might be one that is 10 times larger than this radius. However, the density of events may be affected by the fact that not every absorption event creates a protron (acid) and the fact that the catalytic activity of the acid may increase the density of deprotection events above that of the acid).